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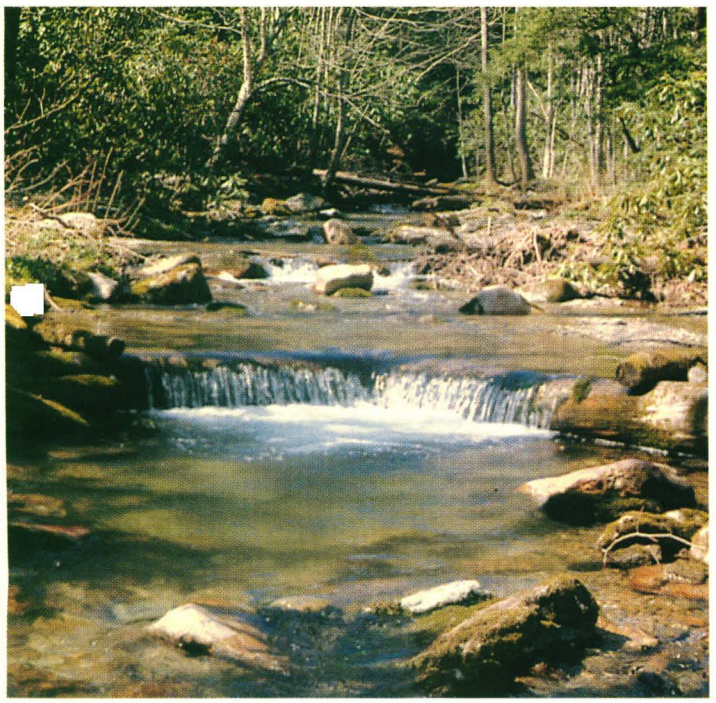
Stream Habitat Improvement Handbook

Technical Publication R8-TP 16

June 1992



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Common Measures and their Metric Equivalents

1 inch	2.54 centimeters
1 foot	0.3048 meter
1 mile	1.6 kilometer

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STREAM HABITAT IMPROVEMENT HANDBOOK

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Illustrations by Barry Nehr

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INTRODUCTION

Purpose

This handbook provides fishery managers with instream structure designs that may be used to correct and/or improve fish habitat deficiencies over a broad range of conditions. With the exception of the fish barrier, the primary objective of the designs is to create deeper water, remove sediment by flushing action, add cover for fish, or add substrate and food for other aquatic organisms. Projects that add large woody debris often accomplish all these objectives.

Scope and Origin of Designs

The majority of the designs are for structures that can be installed with hand labor and tools. Others require heavy equipment to accomplish objectives. As a general rule, careful use of heavy equipment can significantly increase the number of structures installed in a given period of time, with little or no added impact to the surrounding environment.

Most of the designs described are modifications of techniques from other stream-improvement publications. In preparing this manual, designs were analyzed and selected to satisfy specific objectives. The original designs were then modified, as needed, during field tests. Most of the tests took place on trout streams in the Appalachian mountains of Virginia, North Carolina, Tennessee, Kentucky, Georgia, and South Carolina. Limited tests were also made in warmwater streams in other States.

Sediment flushing and added depth are accomplished through scouring action. The scouring causes local movement of instream sediments and, at times, bank sediments. This should not be cause for concern, since long term benefits far outweigh any temporary adverse impacts. Normally, such local scouring adds little sediment. The primary effect is to shift bedload material a short distance downstream, creating the beginning of another meander. As meanders increase and the gradient decreases, current velocity and sediment-carrying capacity are reduced. Creation of these stream meanders, along with deeper water and improved cover, can mean the difference between marginal and better-than-average fisheries. In shallow streams where flow sinks into deep gravel or rubble deposits during drought periods, creation of deeper water or holding pools can be critical.

Cover includes the addition of boulders, logs, rootwads, or any other material that creates hiding or resting areas for fish.

The addition of woody debris, where lacking, can accomplish the above objectives while providing substrate and/or food for other aquatic organisms. Systems such as low-gradient, sandy, coastal-plain streams are especially dependent upon large woody debris to provide suitable conditions for fish and other aquatic communities.

Range of Habitat Conditions

Habitat conditions range from steep gradient reaches (300 to 500 feet per mile) in which the primary substrate is boulders and large rubble, to very low-gradient reaches (less than 10 feet per mile) with shifting-sand substrate.

Stability of streams ranges from excellent to very unstable, depending upon physiographic region. Stream channels within some provinces may change characteristics after each major flood due to extensive bedload movement.

The wide range of conditions encountered throughout the South likely include situations similar to those found in other regions. Therefore, structures suitable for a 15-foot wide, 3-percent gradient, gravel-bottom stream in the South would probably be suitable, with minimum modification, for streams with similar characteristics elsewhere.

Principles of Stream Management

Techniques for improving habitat should be based upon overall management goals of the fishery resource. When the goal is to improve a fishery for large resident brown trout, addition of overhead cover should receive highest priority. When the overall goal is maximizing "put-and-take" fisheries, the addition of structures that will create large open pools may be highest priority. An anadromous fishery requiring maximum spawning habitat development would need yet another approach.

When setting goals, consider not only the target species, but also the associated community organisms and overall aesthetics of the program. Diversity is important in most ecosystems; therefore design your projects to meet the broadest habitat requirements that can be encompassed while still meeting basic objectives. In some projects, aesthetics may be the primary consideration when selecting structure design. For example, wedge dams, K-dams, and double-wing deflectors are used to create scour pools. Under certain conditions, any one of these designs, used exclusively, would likely achieve fish production goals. However, overall aesthetics and diversity objectives would best be met if all three designs are used in a single project.

Economics must also be assessed. Few people enjoy delving into this aspect of a project, yet it is an essential task that must be addressed in order to determine project viability.

Proper planning is critical in any management program. The following action plan provides a logical sequence for implementation:

(1) Establish goals and objectives.
(2) Examine and identify existing conditions and limiting factors.
(3) Prescribe methods to correct deficiencies.
(4) Treat by prescription. Base priorities upon overall management objectives.
(5) Evaluate project to determine if short-term goals are met.
(6) Maintain projects to ensure completion of long-term goals.

Cost Estimates

Cost estimates are given in crew days (8 working hours), rather than dollars to keep your calculations on a current basis in any time period. They are based on a four to six-person crew working in relatively accessible areas using handtools, and cutting logs on site. Installation at times other than low flow periods increases cost and reduces quality of the finished product. Use of heavy equipment in larger streams can significantly increase the number of structures installed at a given time.

Structure durability varies significantly, depending on tree species used, size of logs, and the extent the structure is exposed to air. Logs from small, fast-growing trees, containing little heartwood, deteriorate rapidly. Older trees with a high percentage of heartwood, and rot-resistant species such as black locust and eastern hemlock, are most suitable when exposure to air is a problem. When submerged, all species including yellow-poplar, oak, and white pine are relatively durable. Yellow pine is less durable, but is acceptable in the absence of other species. (The species listed above are found in the South and may not be available elsewhere.)

With proper installation and occasional maintenance, all structures discussed in this handbook should provide benefits for a minimum of 20 years. A few structures placed by Civilian Conservation Corps crews in the 1930's were still in place and functioning after 50 years.

Recordkeeping

Recordkeeping is an important, but sadly neglected, aspect of habitat improvement programs. Due to the dynamic nature of watercourses, it is especially important to keep detailed records of stream habitat work. Occasional maintenance is a necessity and requires specific information about location and design of each structure. A simple form, such as that shown in figure 1, provides space for recording location, design details, materials used, cost estimates, evaluation information, and maintenance performed on individual structures. In addition, a sketch (figure 2) of the entire project is invaluable to maintenance crews and other personnel for determining structure location.

Equipment and Supplies

The following list describes hand-operated equipment useful to a stream improvement crew:

- –Chainsaw.
- –Chainsaw winch.
- –Hand winch (''come-along'').
- –Cobra, Pionjar, or similar heavy but portable jackhammer for driving steel or drilling rock.
- –Hilti or similar lightweight drill for drilling rock or logs.
- –Cable and epoxy for attaching logs to rock substrate.
- –Heavy wire, such as hogwire or chain link fencing (36- to 42-inch width).
- –Fiberglass cloth or fine-mesh wire, such as hardware cloth, for use with the heavy wire.
- –Planking as an alternative to the heavy wire and fiberglass cloth.
- –Staples for attaching wire and cloth to log.
- –Handtools such as clawhammer, axe, mattock (2), pick, 5- to 6-foot steel pry bar (2), shovel (2), fire rake (2), sledgehammer (2), 50-foot fiberglass tape, peavy (2), log carrier (one per two crew members), wire cutters, pliers, cable and clamps, fencepost driver, rebar ''driving head'', hacksaw.
- –Logs – Size of logs will vary with size of stream and type structure. Whenever available, use logs 14 to 16 inches or more in diameter.
- –Steel pins in two sizes cut from reinforcing rod (rebar), and sharpened on one end:
  - 3/4-inch rebar cut 18 inches or longer (depending on log size) for pinning logs together.
  - 3/4-inch rebar cut 54 inches or longer depending on stream size and substrate stability for anchoring logs to the substrate.

DESIGN SPECIFICATIONS AND APPLICATIONS

General Information

As mentioned in the previous section, size of logs depends somewhat on stream size. On shallow streams less than 12 feet wide, 10- to 12-inch logs may be suitable. As a general rule, however, logs should be at least 14 to 16 inches or more in diameter. In this type work, the axiom ''bigger is better'' usually applies!

The distance logs are dug into the streambank depends on bank stability characteristics. In the most stable situations, where logs can be locked behind boulders or root systems, a distance of 3 to 4 feet may be adequate. When banks are composed of unconsolidated gravel, rubble, or other unstable material, a distance of 10 feet or more may be required. Under these conditions, heavy equipment (front-end loaders, backhoes, etc.) may be needed for excavation.

In some situations, logs can be anchored with no excavation by sharpening one end with a chainsaw and driving them into the bank with a bulldozer or other heavy equipment. Abutment logs, or rootwads with the bole attached can be driven as much as 10 to 12 feet into the banks, resulting in complete stability with a minimum of disturbance. Use of these techniques disturbs the soil much less than do hand tools requiring excavation of trenches for the logs. As might be expected, size of logs or rootwads used is limited by size of available equipment. A D-6 Caterpillar or other similar-size equipment will, in most cases, be needed to drive logs in the 14- to 20-inch range. Smaller equipment such as a John Deere 450 or Caterpillar D-4 will, however, handle logs up to a 14-inch diameter in soft banks.

Some banks are rocky for ''driving'', or may involve bedrock. At such sites, anchor the logs by drilling the rock and driving rebar into the holes or placing cable over the logs and then epoxying the ends into the drilled holes.

Use short rebar to join logs. Use longer rebar to anchor logs into the stream bottom. A cutting torch can be used to shape points on these steel pins. Cut a slot or hole through the logs to facilitate driving them. A chainsaw is the simplest and quickest tool for cutting a slot. A power drill may be needed to drill holes through extremely hard wood such as black locust.

A soft, rolled-steel cylinder 6 inches long by 2 inches in diameter with a 7/8- or 1-inch diameter hole drilled 3 inches deep into its length, can be used as a ''driving head'' for the pins.

Low-flow periods are optimum for structure site selection and installation. In the South, this generally occurs during late summer and early fall, although suitable conditions can occur any time from May through early November.

STREAM IMPROVEMENT STRUCTURE

NATIONAL FOREST Nantahala DISTRICT Wayah

Stream Big Indian Cr. Structure # 1

Location of structure First structure above the mouth of Big Shoal Cr. (approx. 100')

Type structure Wedge dam Date of construction Sept. 1986

Materials used Hemlock logs, Hogwire, Hdw. cloth

Man days & estimated cost of structure 3 man days - $350

Purpose of structure to create a pool & improve fish cover

Evaluation of structure at least one year after construction structure has created a pool 30" deep in a stretch of water normally only a few inches deep

Maintenance performed (date & brief description) No maintenance to date (6/92). Only work needed at present is minor replacement of rocks in wings (see sketch).

SKETCH

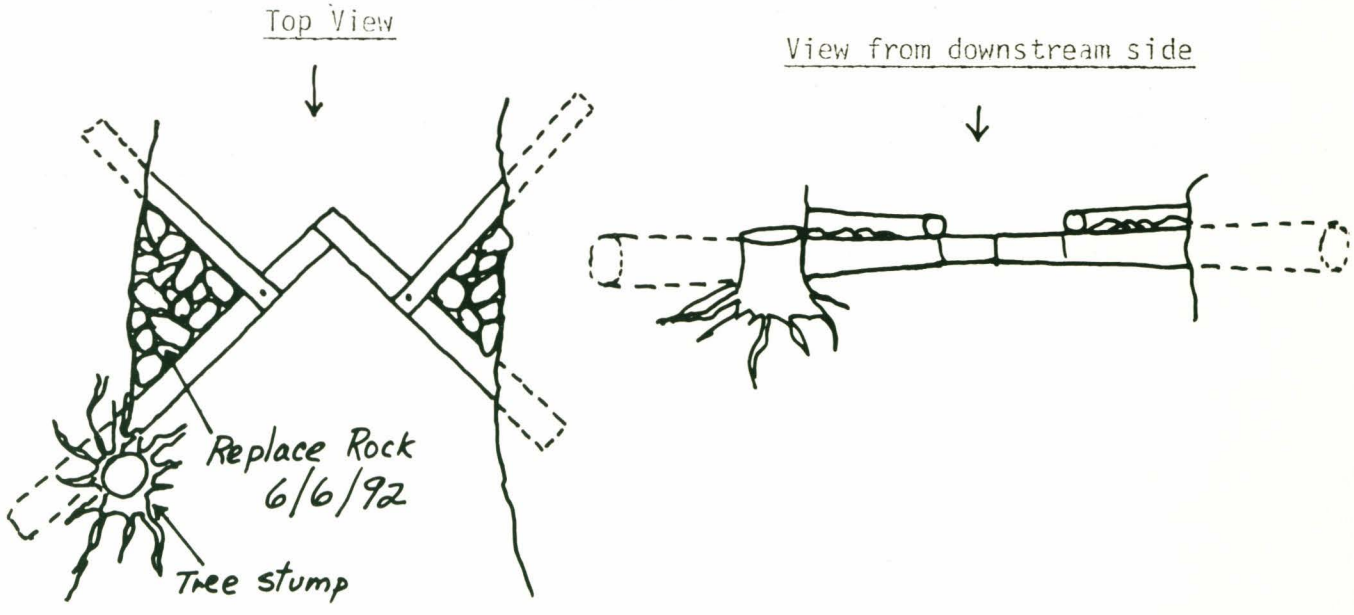


Figure 1.–Example of record form.

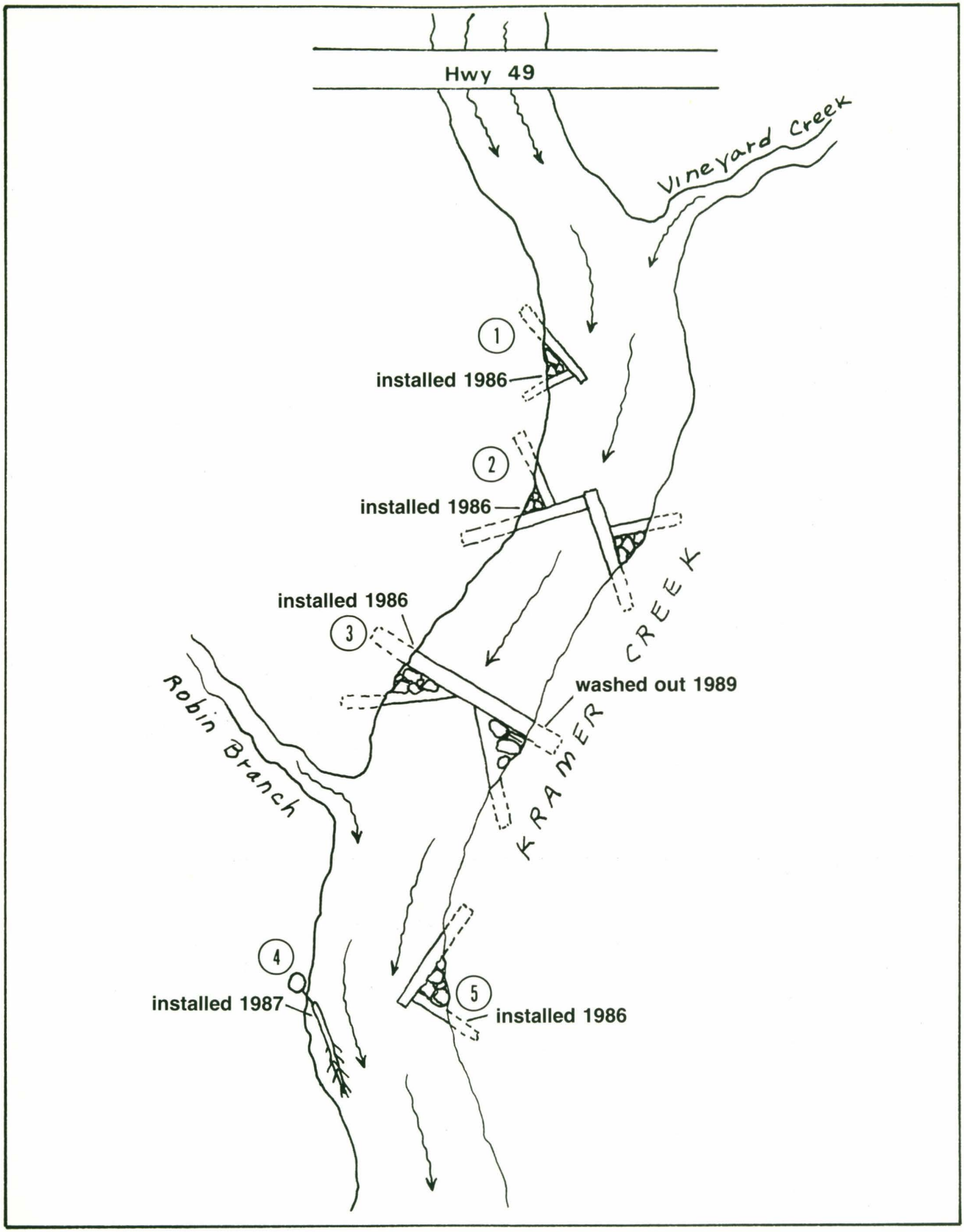


Figure 2.–Kramer Creek stream improvement project.

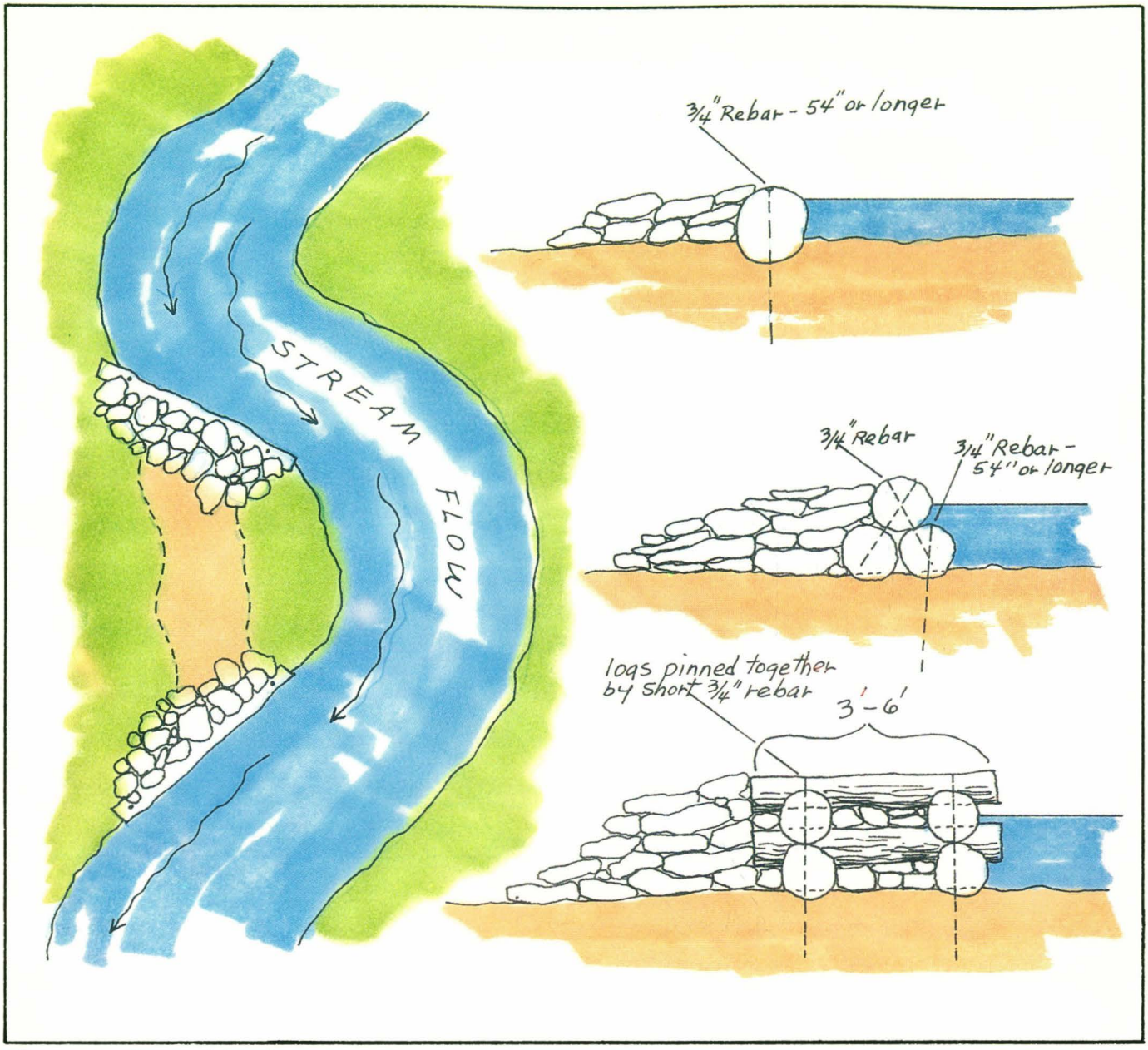


Figure 3.–Channel blocks.

Channel Block

Purpose – In any improvement project, top priority should generally be given to consolidating braided channels. Low summer flows moving through several small channels hold fewer large fish and in some cases will not allow up or downstream movement of fish. By consolidating flow into a single, deeper channel, additional fish-holding habitat can be created. In addition, potential temperature problems can be avoided (wide, shallow areas tend to warm quickly), and migration routes restored.

These structures may also be used to maintain stream meanders where flood flows have eroded a channel through the meander (figures 3 to 5). The structure holds normal or moderately high flows in the meander channel, but still allows flood waters to overflow into the blocked channel.

Design – Since these structures are placed in critical areas bearing the brunt of flood waters, special care must be taken to ensure stability. Single logs may be used with success in small streams. Triple log and crib structures give better results and are less likely to wash out in larger (over 15 feet wide) streams. Generally, triple logs can be used in relatively stable streams 15 to 25 feet wide. The log crib, filled with gravel and rubble, is generally more suitable for larger, unstable streams.

Placement – Channel blocks are usually installed in braided channels or in stream meanders where flood waters are creating an oxbow. Place blocks at the lower end of the flood channel as well as the upper end, to prevent head cutting.

Advantages – Triple logs or cribs tend to leak less water than do single logs. However, single logs are much easier and cheaper to install.

Cost – Generally, three to four single-log structures or two to three triple-log structures can be installed per crew day in 15- to 20-foot wide channels. One hand-filled crib may require from 1 to 2 days to construct.

Figure 4.–Channel block - single log.

Photo Courtesy of Pennsylvania Game and Fish Commission.

Figure 5.–Channel block - crib.

Boulder Placement

Purpose – The primary goal is to provide overhead cover and resting areas. Added depth is also created by scouring resulting from reduced channel capacity and increased current velocity.

Design – For best results, use large, irregular-surfaced boulders. The more irregular the surface, the more "pocket" or hiding space will be available to fish. Where channel width allows, best results are obtained by placing the boulders in groups (figures 6 to 8).

Placement – Boulders can be used in most stream situations, including riffles, runs, flats, glides, and open pools. Greatest benefits are likely to be achieved in currents exceeding 2 feet per second.

Advantage – No other materials are needed for installation. Boulders also present a more natural appearance than do most structures.

Disadvantage – Boulders are not always available at project sites. Heavy equipment may be necessary to move them into place.

Cost – Cost depends upon the distance boulders are moved and the type of equipment used. If conditions are suitable and boulders are plentiful, a frontend loader could easily place 25 or more a day.

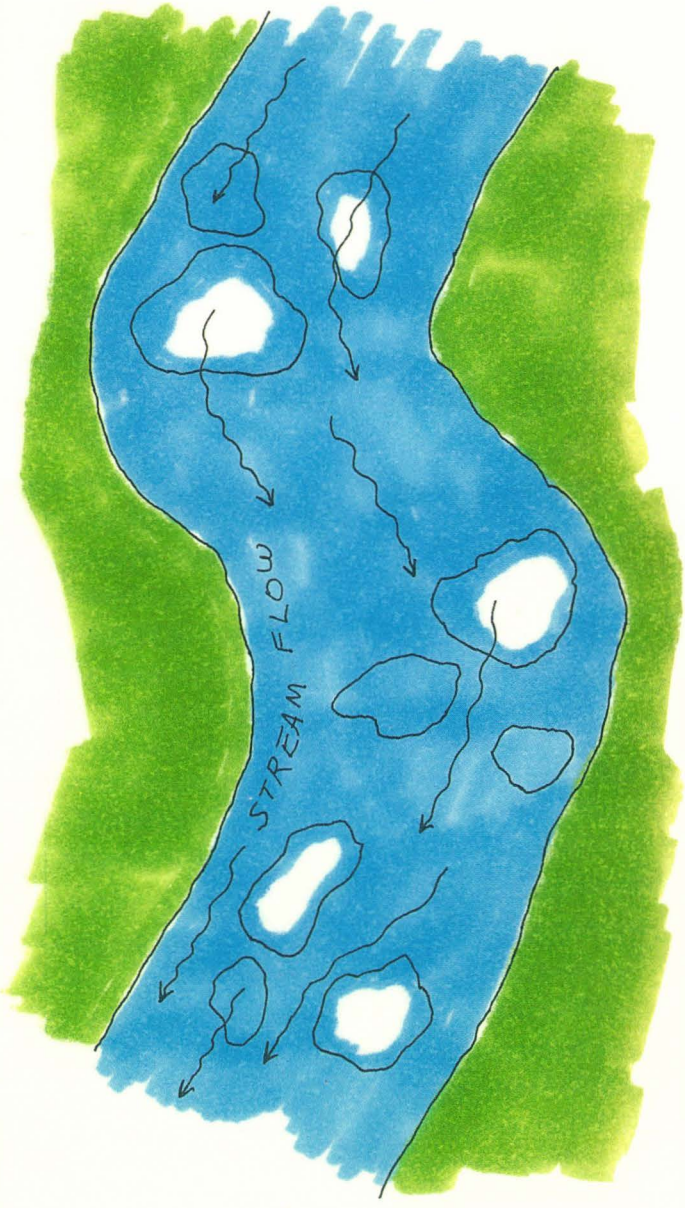


Figure 6.–Boulder placement.

Photo Courtesy of Lola National Forest

Figure 7.–Boulder cover.

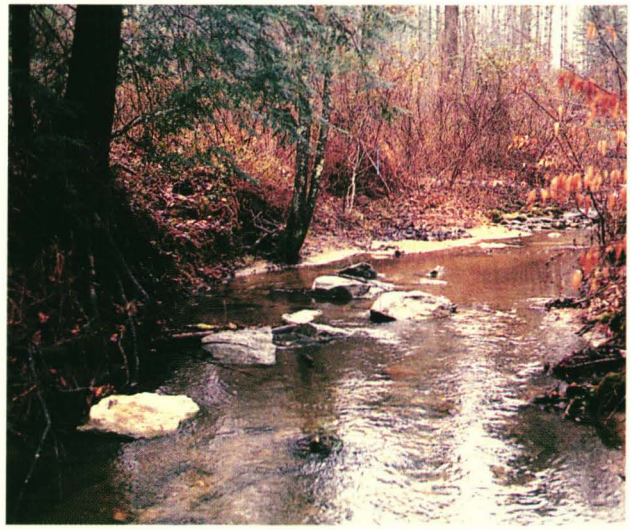


Figure 8.–Boulder cluster.

Cover Logs and Rootwads

Purpose – These structures provide overhead cover in sections of stream where existing water depth may be adequate, but cover is lacking. See figures 9 to 16.

Design – Cover logs can be any shape, length, or size, but best results are attained with large (over 16 inches diameter), crooked logs. They provide an irregular surface, resulting in maximum turbulence along the edge of the log. Logs with stubs of limbs several inches long create additional turbulence and spot scouring. Large stumps or rootwads, if available, provide ideal cover. Where such material is unavailable and logs are small and straight (use nothing less than 10 inches), a slab can be chainsawed from the bottom, creating a "bench" effect (figure 10).

Logs placed out in the channel can be pinned into gravel and rubble substrate with 3/4-inch rebar 54 inches or longer. Logs placed against streambanks can be anchored with rebar as mentioned above, or pinned to abutment logs in the bank. Where bedrock is prevalent, use a portable jackhammer to drill holes. Logs can then be attached with rebar driven through and into the hole, or with cable and underwater epoxy.

Install abutment logs by excavating trenches or drive them into the bank with heavy equipment. Drive rootwads with 8- to 12-foot boles flush with the streambank (figure 9). If the bank is unstable, place logs across the rootwad boles, against the bank, as shown in figure 9, and pin them. "Footer" logs underneath the boles may be needed in highly unstable streambank material.

Placement – Ideal locations are open pools, runs, or flats at least 6 to 8 inches deep (preferably deeper). In these locations, logs are placed parallel, or at a slight angle, to the flow (figure 10). Logs installed along stream banks are usually placed at a slight angle to flow. The best bank locations are in stream meanders or in conjunction with deflectors (see "Deflector and Cover Log").

Advantage – Cover logs and rootwads are the simplest and least expensive of the log structures discussed. Under certain conditions they provide optimum cover and present a natural appearance. In addition, they are suitable for use in any size stream, and have less impact on channel capacity and flow characteristics than do other structures. Maintenance is minimal.

Disadvantage – Unless logs are large and of irregular shape, they may become partly or completely covered with sediment deposits. Benefits may be minimal in water less than 6 to 8 inches deep. In sandy or other highly unstable substrate, there may be no feasible means of anchoring them, other than into the streambank.

Cost – When logs are handy and rebar is used to anchor them into the substrate, a crew can install 10 or more cover logs per day. Where abutments must be dug into banks to hold them in place, less than 10 structures per day is a more realistic goal. A two- or three-person crew with a dozer can collect and install six to eight or more rootwads per day.

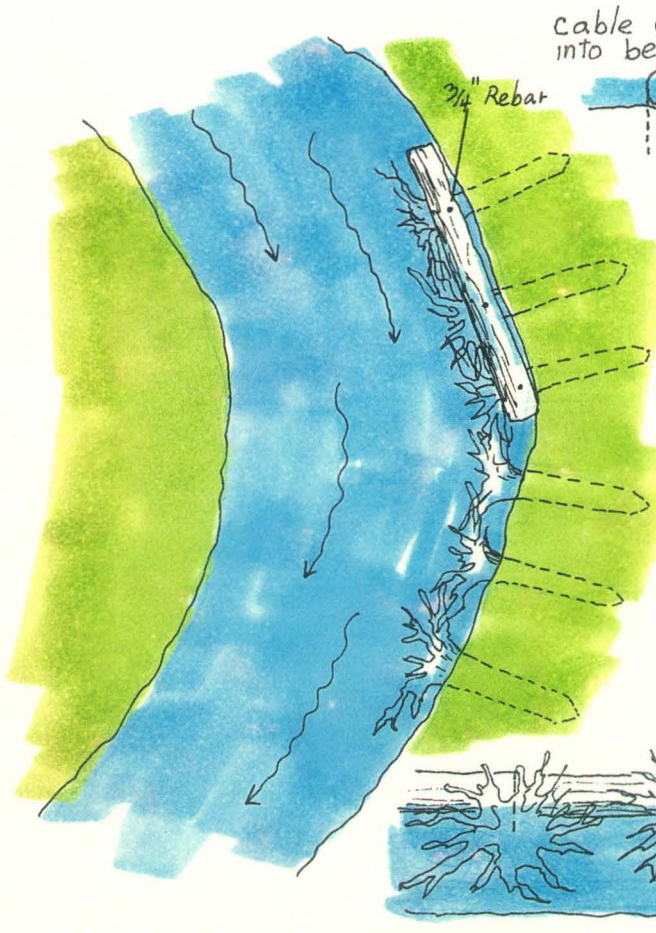


Figure 9.–Cover logs and rootwads.

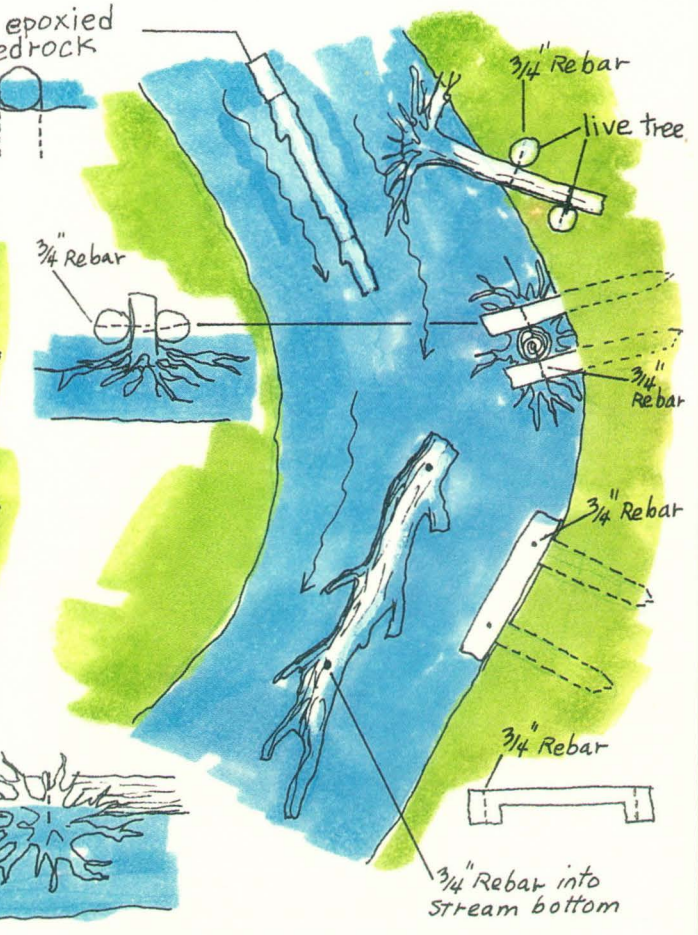


Figure 10.–Cover logs and rootwads.

Figure 11.–Crooked cover log with limb stubs.

Figure 14.–Driving rootwads.

Figure 12.–Cover log collecting woody debris.

Figure 15.–Single rootwad driven into bank.

Figure 13.–Rootwads driven into bank.

Figure 16.–Rootwad pinned to tree with rebar.

Tree Cover

Purpose – Trees placed in proper locations provide several benefits. They provide excellent overhead cover and an ideal substrate for aquatic organisms. In addition, trees serve as deflectors constricting wide, shallow channels, thus increasing stream velocity, resulting in sediment flushing and deeper scour pools.

Design – Trees can be cut and felled directly into the stream (in a downstream direction) with the axis parallel or at a 10- to 20-degree angle to the streambank. If trees are located properly, they can be hinge-felled in place (figure 17). Where trees are hinge-filled, they can also be cabled to the stump to ensure stability. If not, they can be cut, placed, and then attached with cable to the stump (figure 18). In smaller streams, understory shrubbery, such as rhododendron, can be hinge-felled in the same manner as trees. If heavy equipment is available, entire trees including rootwad can be uprooted, moved, placed, and anchored to abutment logs driven into the streambank (figures 19 to 21). These placements give a natural appearance and provide ideal cover for fish, and substrate for other aquatic organisms.

Placement – Place trees or shrubs in any section of stream large enough that such installation will not create serious bank erosion. Greatest benefits probably occur in wide, shallow streams with sand or gravel substrate.

Advantage – Under certain conditions trees can provide excellent benefits with little expense. In larger streams with unstable substrate and no means of attaching cover logs, trees may be the only feasible alternative.

Disadvantage – Small channels may preclude the use of trees. Suitable trees may not always be nearby. Where trees cannot be felled directly into the stream, heavy equipment will be required for placement.

Cost – Where trees can be hinge-felled or dropped in place, two workers could cut and cable eight to twelve trees per day. Where trees must be moved by heavy equipment, four to eight trees per day would be a more reasonable figure.

Figure 17.–Tree Cover.

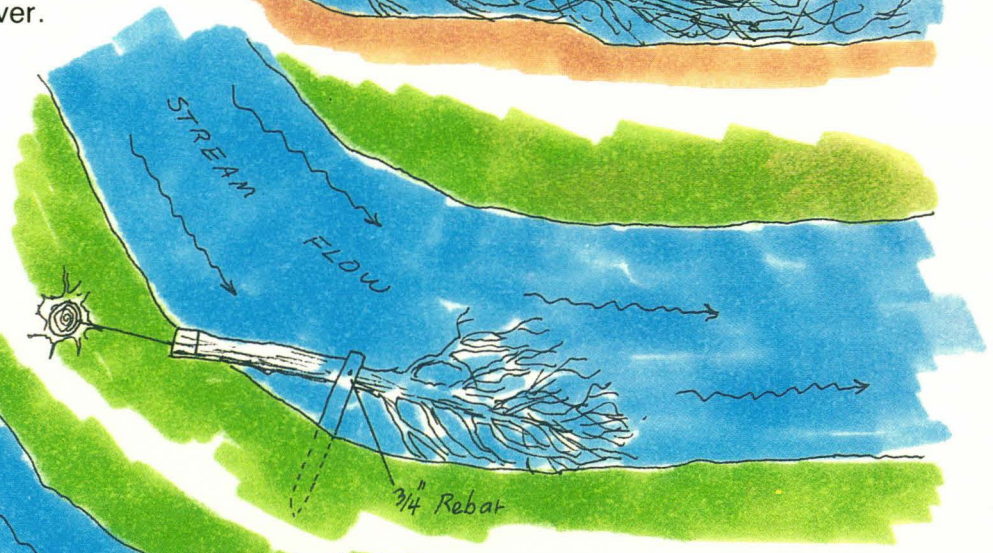


Figure 18.–Tree Cover.

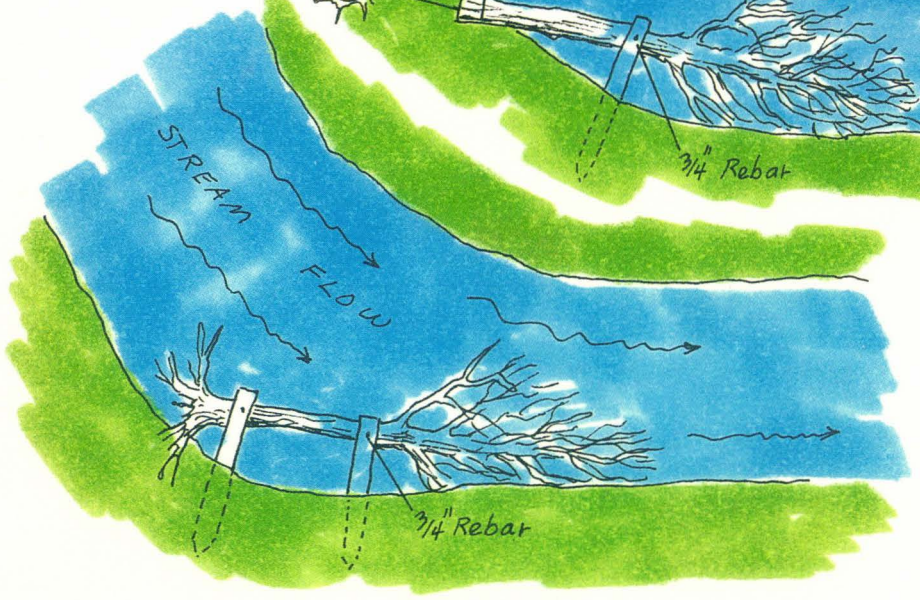


Figure 19.–Tree Cover.

Figure 20.–Log driven into bank and pinned to tree.

Figure 21.–Tree cover.

Bank Crib with Cover Log

Purpose – Protects unstable banks; at the same time provides excellent overhead cover for fish.

Design – A simple crib with abutment logs should extend as far back into the bank as necessary to assure structure stability (4 to 6 feet in stable soils and 10 feet or more in unstable soils). Put the lower abutment logs near water level (figure 22) and extending 18 to 24 inches from the bank. The cover log can then be pinned to the crib log and the lower abutment (figure 23). The structure can be from one to several logs high, depending on bank height (figure 24).

Placement – This structure can be used in any area with unstable banks.

Advantage – The design accomplishes two objectives. It ensures bank stability and creates excellent cover at the same time. The only materials required are logs on site and rebar to join them.

Disadvantage – Installing the structures is fairly time-consuming, due to the amount of digging required. Eroding banks at some locations require abutment work, but the water is too shallow to make effective use of cover logs.

Cost – One crew should install 20 to 30 feet of crib (two crib logs high) per day if logs are reasonably close to the site. Use of heavy equipment to drive abutments and place crib logs can increase output four- to fivefold.

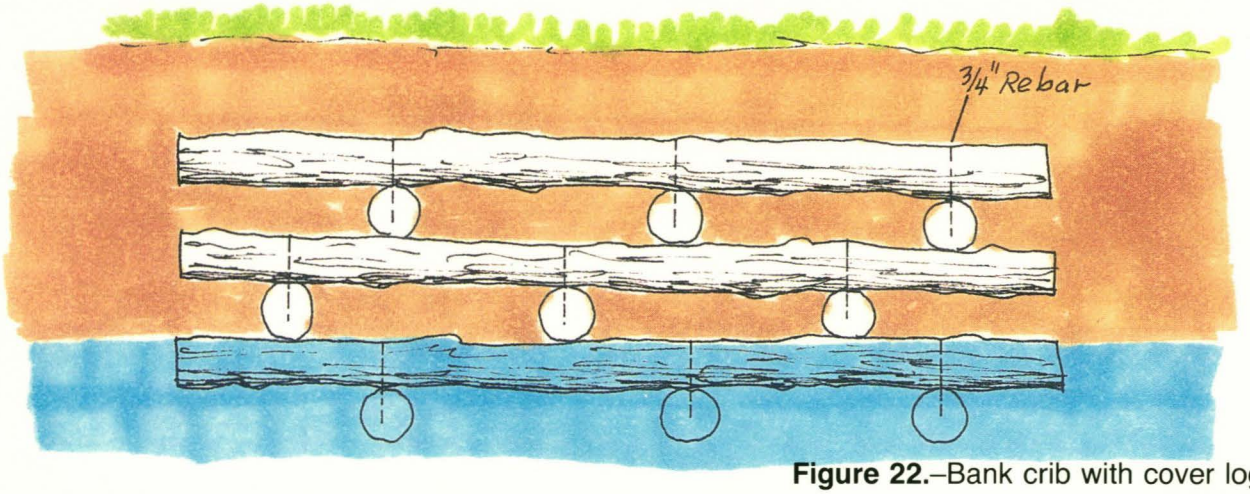


Figure 22.–Bank crib with cover log.

Figure 24.–Bank crib.

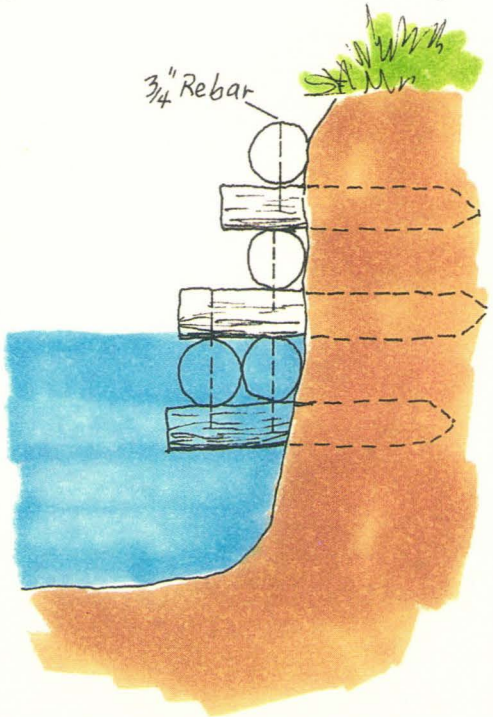


Figure 23.–Bank crib with cover log, side view.

Log and Bank Shelter

Purpose – Provides overhead cover. Some streambank protection is also provided, although less than with cribs. Brush and other woody material attached to the platforms provide additional benefit by harboring insects and other fish food organisms.

Design – The finished shelter is a form of cover log spanning a stream meander with a choice of various materials to create a shelf. The materials used to cover the space between the main log and the bank can consist of rock, logs, or simply brush. Figures 26-28 and figures 29-31 illustrate two different techniques in constructing the shelf. In figures 26-28 dig or drive the abutment logs and the ends of the main log into the bank and then pin them together with rebar. The structure will last longer if all logs are submerged. Attach brush or debris so that portions are above and below the water surface.

Placement – These structures are most suitable for use in low-gradient stream bends or meanders where open pools are already present. Use them with a deflector to enhance results.

Advantage – Materials are cheap, and a comparatively large area of overhead cover is provided at each site. Brush provides maximum surface for both terrestrial and aquatic insects.

Disadvantage – Where streambanks are high, use of hand tools to excavate channels for the logs can be very labor intensive. Use of heavy equipment to simply shove the logs into the bank, however, can make this one of the more cost-effective designs.

Cost – Output should range from two structures per crew day on a small stream with low banks (2 to 4 feet) to one per day on larger streams with higher banks. Use of heavy equipment to drive and place logs can increase output four- to fivefold.

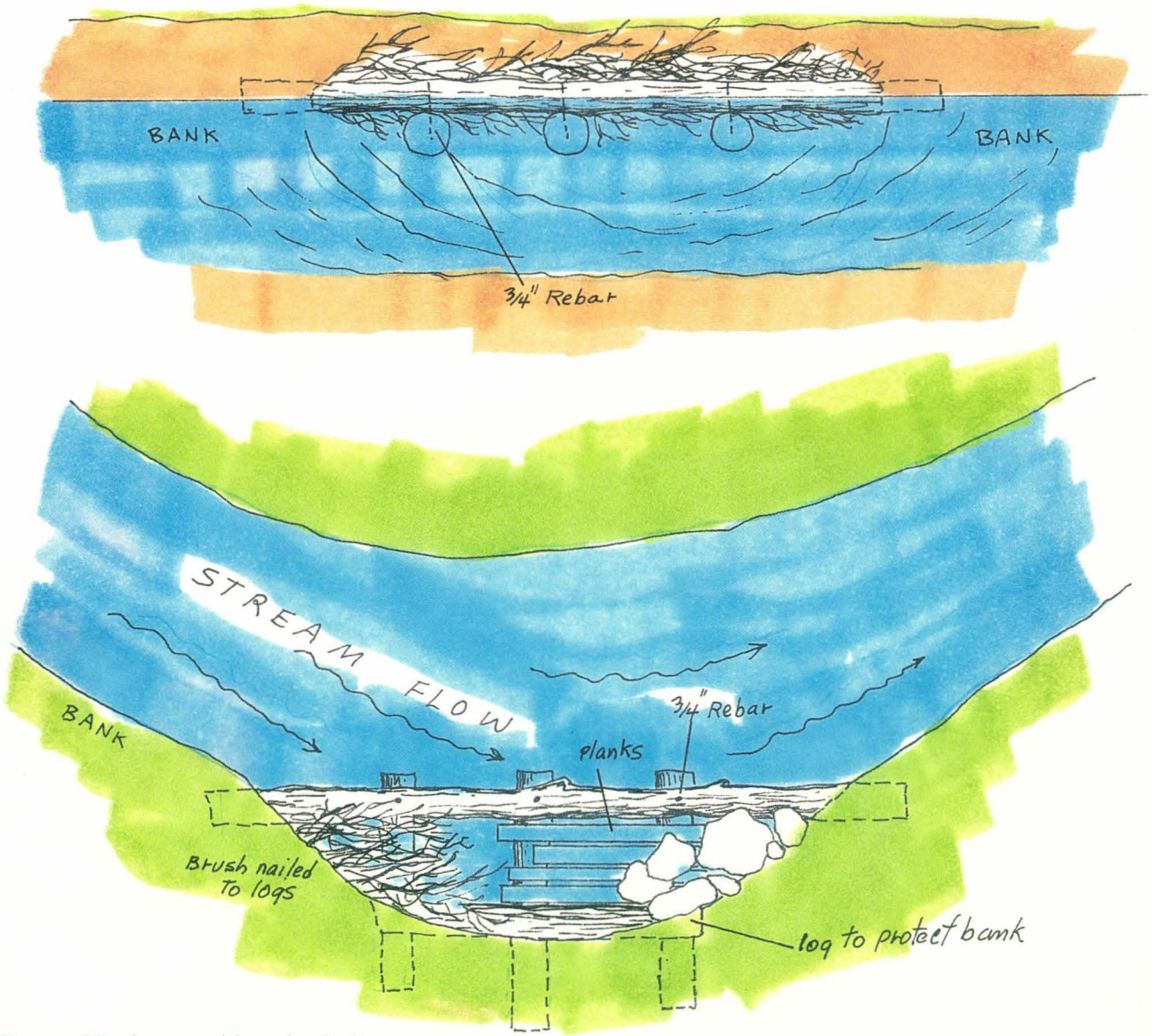


Figure 25.–Log and brush shelter.

Figure 26.–Placing abutment log on main log.

Figure 29.–Driving 12′ logs for bank shelf support.

Figure 27.–Adding slab rock and tamping bank.

Figure 30.–Adding planks for shelf.

Figure 28.–Log and bank shelter 6 weeks after installation.

Figure 31.–Shelf with rock added 6 weeks after installation.

Single-Wing Deflector

Purpose – Constricts and diverts water flow so that stream meanders and pools are formed by scouring and relocation of fine sediment and gravel (figures 32, 33).

Design – Use logs at least 14 inches in diameter, except in the very smallest streams. Install the logs several inches into the streambed. The finished structure can rise 6 to 18 inches above normal low flows, but should always be less than streambank height. The higher the structure, the greater the scouring action will be during storm flow. Low-flow stream width must be narrowed in most cases by 70 to 80 percent between the tip of the deflector and the streambank to achieve desired results. Channel cross section is restored and stream velocity reduced as scouring forms a pool extending from the junction of the main and brace log to the far bank.

Logs are joined by rebar and held in place by extending 4 to 6 feet of the main log into the streambank. In streams over 10 feet wide, drive rebar through the main log into the streambottom 3 to 6 feet from the tip of the structure.

Place the main deflector log at approximately a 30- to 35-degree angle to the streambank. Pin the brace log to the main log several feet from the tip at about a 90-degree angle. This angle can vary somewhat, but should permit waters overtopping the structure to spill toward the center of the stream rather than the streambank. Use large flat rocks, when available, for fill material. Install sod or soil and seed as a final measure to ensure long-term stability and improve aesthetics. Hold the sod in place with welded wire or similar material, if needed. Where removal of rock from the stream is undesirable, fill the crib with logs pinned in place. Use log fill at the tip to form an overhang. This material is better than small rock and gravel fill, which tends to slough and fill the scour pool.

Placement – Deflectors are quite versatile and can be placed in sites ranging from steep gradient chutes with heavy rubble bottoms, to wide shallow flats with sand or silt substrate. The most suitable locations are in wide shallow riffles or flats. When possible, divert water into a relatively stable section of streambank. Ideal locations are where water is diverted into large boulders, overhanging trees or stumps, and sections of bank with interlocking root systems that can be undercut without sloughing significantly. Where sloughing occurs, add an abutment or cover log to hold the bank in place and to provide overhead cover (see "Deflector and Cover Log"). Where water is diverted against boulders, stumps, or other stable objects with a short span, the apex or tip of the deflector should be placed opposite or slightly upstream from the object. Where cover logs or extensive root mats provide a longer surface, the tip of the deflector should be located about one-third of the distance above the lower end of the log or rootwad. By placing the deflector towards the lower end, the constriction or damming effect will create deeper water along the entire upper two-thirds of the log. These devices are suitable in streams up to 30 feet or more in width.

Advantage – Deflectors are significantly cheaper to install than dam type structures. They're effective in sections of stream where the banks are too low for dams. They are also suitable for use in streams too wide for dams.

Disadvantages – When maximum depth is the objective, dam-type structures generally create a deeper scour pool than do deflectors. Some high-gradient reaches have water with flows exceeding 3 feet per second and substrate composed of large rubble or other coarse material. At these sites install dams that break gradient and more effectively reduce current velocity. The dams generally provide better cover and resting or holding areas.

Cost – Three to four deflectors can be installed per crew day in streams 10- to 15-feet wide.

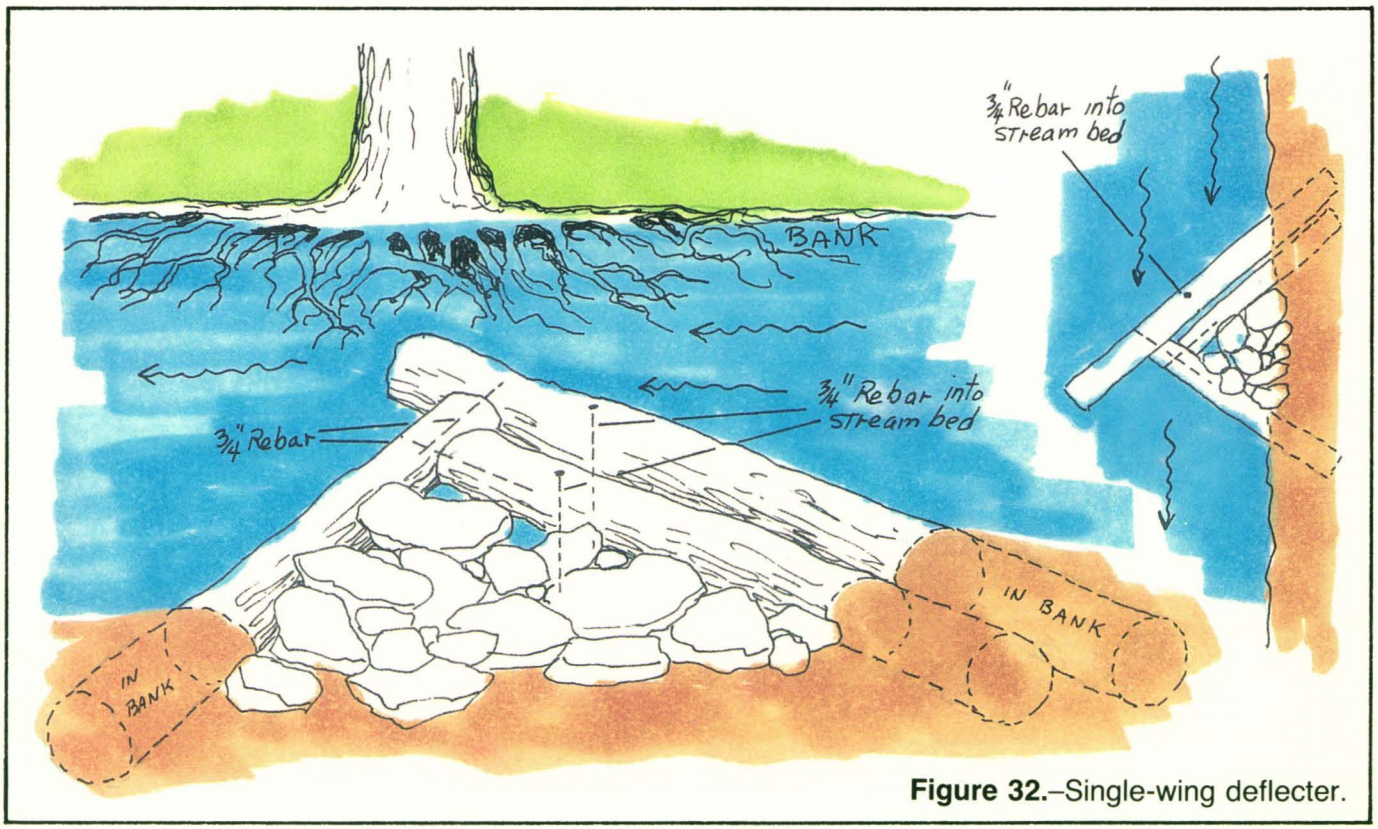


Figure 32.–Single-wing deflecter.

Figure 33.–Single-wing deflecter.

Figure 34.–Deflecter and cover log.

Deflector and Cover Log

A deflector and cover log is similar to a single-wing deflector. The cover log ensures bank stability where suitable boulders, tree stumps, or stable banks are lacking (figures 34, 35, 37). Two to three deflector-cover log combinations can be installed per crew day in streams 10 to 15 feet wide.

Double-Wing Deflector

Purpose – Creates midchannel pools through scouring action in shallow sections of streams.

Design – This combination of structures includes two singlewing deflectors placed on opposite streambanks (figures 36, 38) with the two apexes narrowing the low-flow channel by as much as 80 percent (i.e., a 20-foot wide channel would be narrowed to 4 feet between tips of deflectors). This degree of constriction in gravel and small rubble usually results in a scour pool extending 2 to 3 feet under the tip of each deflector as channel cross section returns to equilibrium.

Placement – This combination of structures is especially suitable for shallow sections of stream where the gradient is too steep for effective deflector and cover log combinations, and where banks are too low to install wedge or K dams.

Double-wing deflectors can also be used in low-gradient sections, but in most cases the small meanders created in such areas by a series of deflector-cover log combinations provide better results than can be attained with double-wing deflectors.

Advantage – The double-wing deflector is suitable for use in situations where deflector-bank logs and small dams are not as effective or feasible. If installed properly, scour pools equal in quality to those produced by small dams can be created at less cost.

Disadvantage – These structures provide only one break in gradient or resting area (the scour pool). In contrast, dams often provide a small flat or resting area above the structure in addition to the plunge pool.

Cost – The paired structures can, in most cases, be installed at two locations per crew day in smaller streams (10 to 15 feet wide). In large streams, one and one-half structures per day is more realistic.

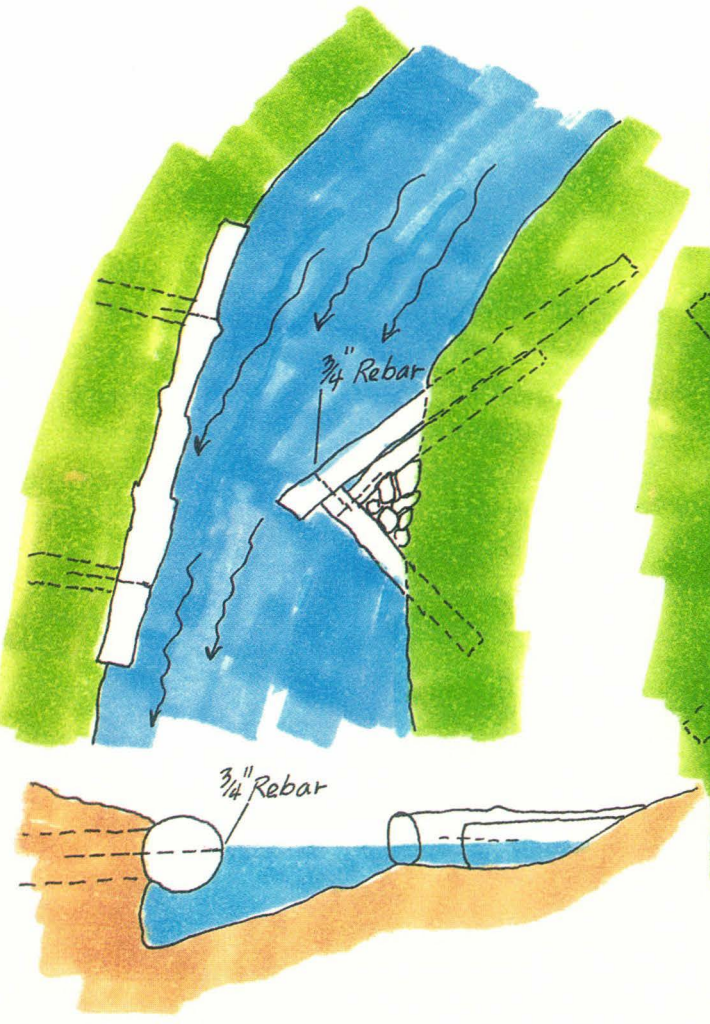


Figure 35.–Deflecter and cover log.

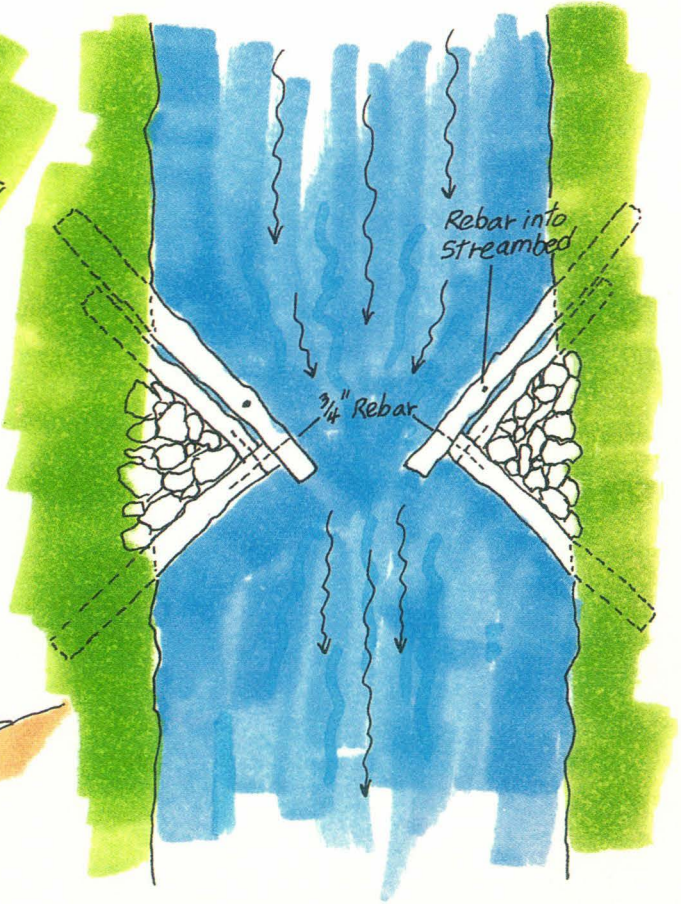


Figure 36.–Double-wing deflecter.

Figure 37.–Deflecter and cover log.

Figure 38.–Double-wing deflecter.

Channel Constrictor

Purpose – Serves as a modified deflector designed to create overhead cover similar to that provided by undercut banks.

Design – Install channel constrictors alone or in pairs. Each structure consists of a main channel log and two brace logs (figures 39 to 41). Place the main log at a slight angle to flow. Pin the two brace logs to it at a 45-degree angle. The main log can be from 10 to 30 feet long and should be as large as can be handled. A rough, crooked log often creates ideal cover. The intent is to provide an undercut for the entire length of the main log (both logs if structures are paired). On smaller logs, where overhang is not created through sheer size, cut a slab from the underside of the log to provide additional space (see "Cover Log").

Put at least two fill logs behind the main channel log (figure 39). Rock fill placed against the channel log tends to slough as the bottom scours, filling and reducing fish holding area.

Reduce channel width by 70 to 80 percent between the two main logs (where two structures are paired opposite). Allow slightly less distance between the lower ends than the upper ends. Where banks are unstable, it is critical to keep structure profiles as low as possible.

Placement – Channel constrictors provide best results when placed in long, straight, low-gradient stretches of stream.

Advantage – Constrictors provide more extensive overhead cover than do conventional deflectors.

Disadvantage – Considerable experience is needed to install these structures properly. In most cases, failure has resulted from being too conservative when constricting the stream channel, and placement in reaches with excessive gradient.

Cost – One pair of structures per day is a reasonable goal.

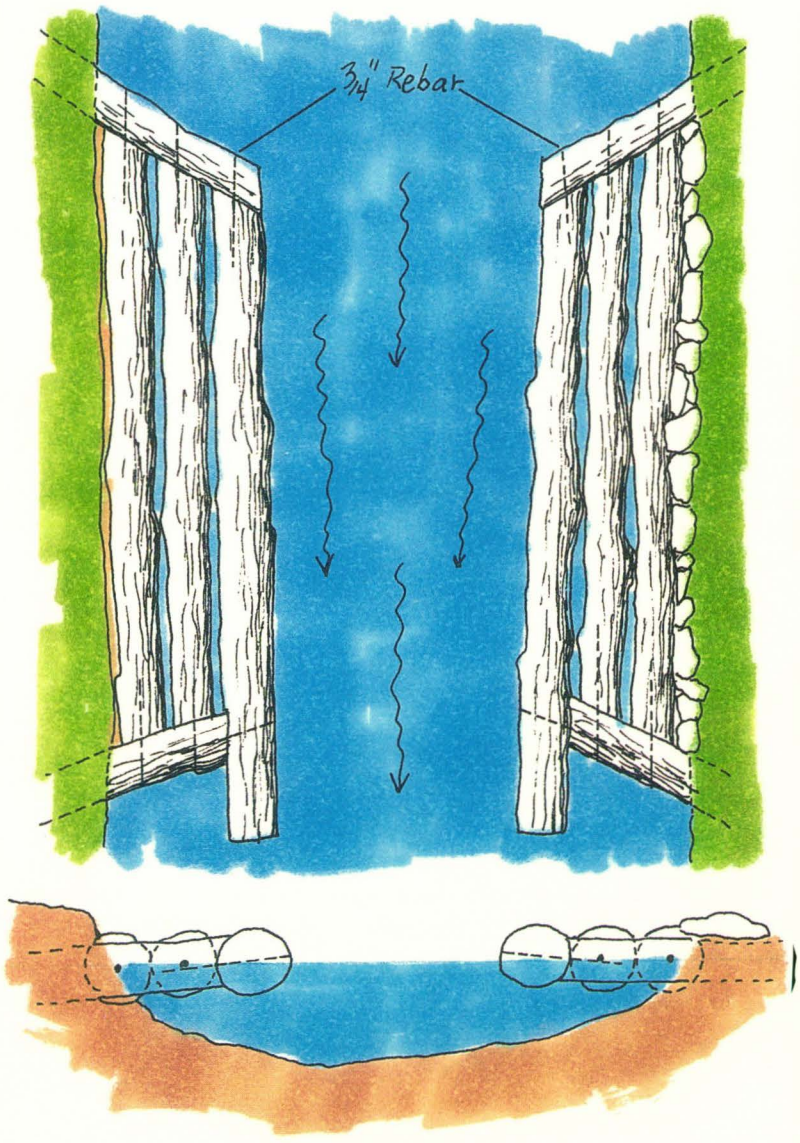


Figure 39.–Channel constrictor.

Figure 40.–Before channel constrictor installed (4- to 6-inches deep).

Figure 41.–After channel constrictor installed (18- to 20-inches deep).

Cross Log and Revetment

Purpose – Creates a scour pool formed by water pouring over the top of the cross log or by forcing its way underneath. Revetment logs create overhead cover and protect the bank at the same time.

Design – Dig the cross log into the streambottom at an angle of 30 to 45 degrees from the direction of streamflow. Place the revetment log at a slight angle (5 to 10 degrees) from streamflow (figures 42, 43). The junction of cross and revetment logs should be upstream, with that end of the cross log at least 6 inches lower than the other end. Both ends of the cross log should extend 3 or more feet into the bank, depending upon bank stability. Pin the revetment and cross log together into the streambottom with long rebar. Also pin the lower ends of both logs to the streambottom with rebar. Results will be best if the revetment and cross logs are notched at their junction.

Placement – These structures work best in low-gradient sections of streams. Use them in straight reaches or, with even better results, at the beginning of wide, shallow bends with marginal pools or cover.

Advantage – This structure requires only on-site materials, and presents a very natural appearance. It does not require well-defined streambanks.

Disadvantage – It is difficult to dig the trench deep enough for proper placement of the cross log. The top of the cross log should be no more than a few inches above the existing stream bottom.

Cost – A crew can install one or two structures per day in streams 10 to 15 feet wide.

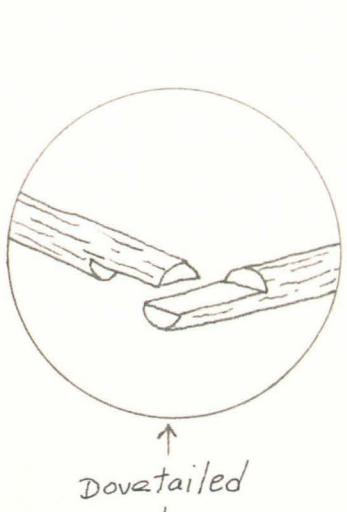


Figure 43.–Cross Log and revetment.

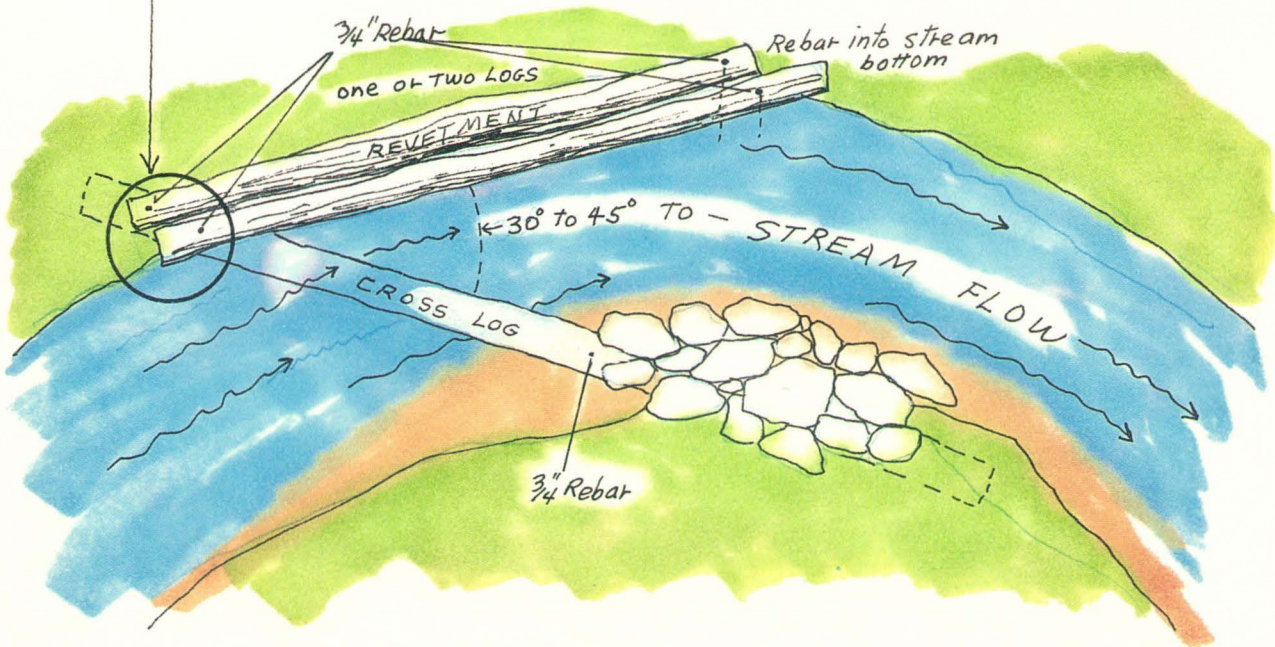


Figure 42.–Cross log and revetment.

Wedge Dam

Purpose – Create pools or deeper water through scouring action in shallow sections of stream. In continuous, steep gradients, the short, upstream break in gradient also provides resting area, often holding more fish than does the deeper pool below. The quiet water above the structure and the edges of the pool below also act as a trap for organic material used as food by stream invertebrates.

Design – The two main logs in the dam face upstream at a 45-degree angle to streamflow with the two brace logs pinned to the main logs at about a 90-degree angle (figures 44 to 47). Butts of the two main logs extend into the streambank 3 to 6 feet, depending upon stability of the bank (deeper in unstable soils). A 6- to 12-inch drop along the top of the log from the bank to the apex is desirable; this is usually achieved through log taper and by digging the trench deeper at the apex than at the bank. Dig the main logs into the stream bottom as deeply as possible. Logs should be as large as possible; select logs at least 10 to 12 inches in diameter for small streams (less than 10 feet wide) and 14 to 16 inches in larger streams.

Once the logs are in place, staple hogwire or other heavy wire, such as chain link fencing, to the upper side of the log. Then place fiberglass cloth or hardware cloth on top. The cloth or small mesh wire seals the structure, and the heavy wire provides strength to hold the fill material in place. Put a layer of large flat rocks on the wire. Next, add a layer of gravel and then another layer of large rock on the gravel. If preferred, nail 4- to 6-foot boards to the upper side of the dam log in lieu of wire. Fill the cribs at the bank with a mixture of large rock, gravel, and dirt. Spillway height should be 6 to 12 inches.

Placement – Wedge dams are generally limited to steep-gradient streams less than 30 feet wide. Well-defined streambanks are another requirement. Ideal locations are at a break in gradient with a steeper section immediately upstream.

Advantage – Wedge dams almost always create a fair to excellent scour pool, even in heavy rubble. Small dams create more dramatic and noticeable changes than do other types of structures.

Disadvantages – Dams cost more and require more maintenance than do other structures. The most common failure is washing underneath; nonetheless, the wedge dam is less prone to this type of failure than is the K dam.

Cost – One structure per crew day can be installed in streams 10 to 15 feet wide.

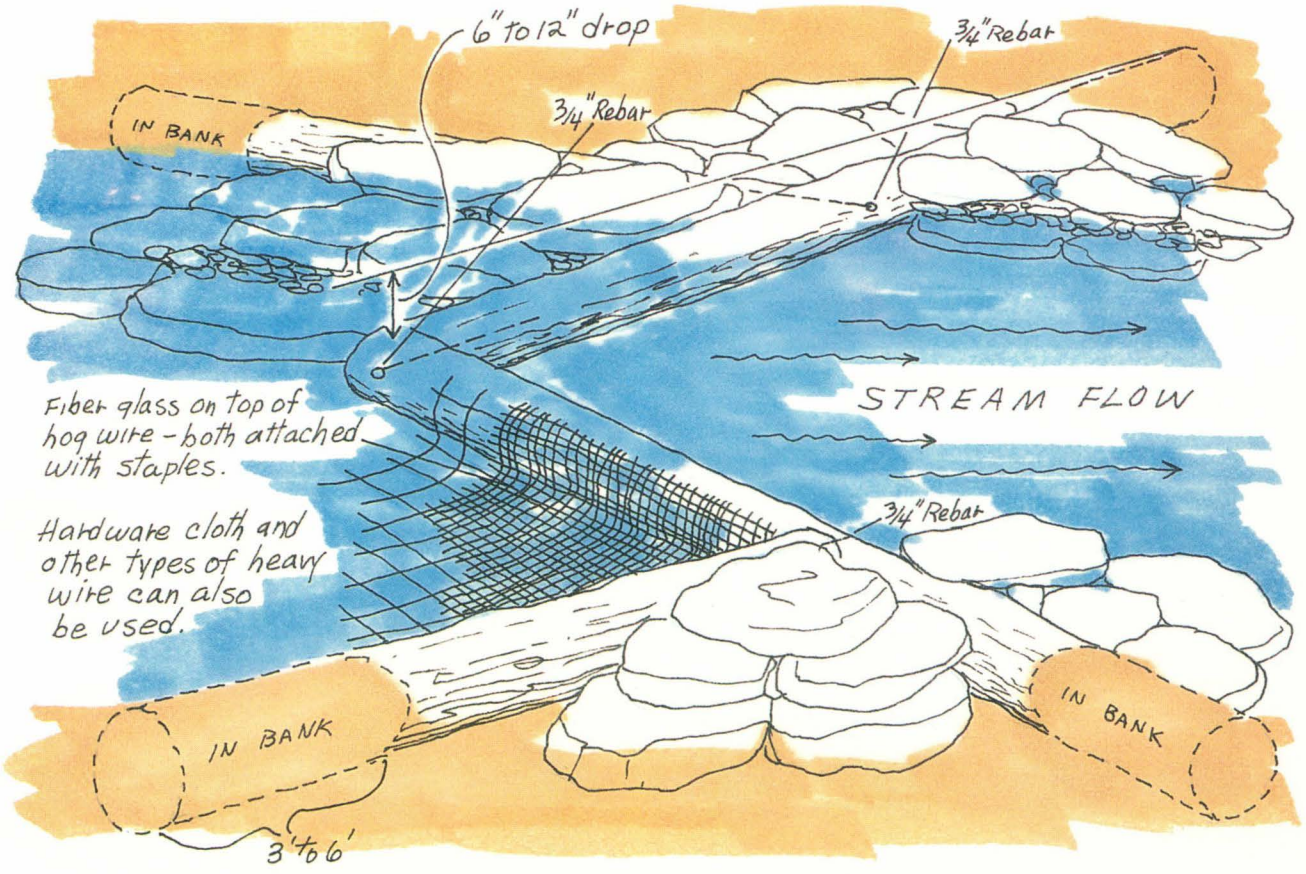

6" to 12" drop
3/4" Rebar
3/4" Rebar
IN BANK
STREAM FLOW
Fiber glass on top of hog wire - both attached with staples.
Hardware cloth and other types of heavy wire can also be used.
3/4" Rebar
IN BANK
IN BANK
3' to 6'

Figure 44.–Wedge dam.

Figure 45.–Wedge dam elevated for pinning.

Figure 46.–Wedge dam with wire added.

Figure 47.–Wedge dam after 13 years.

K Dam

Purpose – Basically the same as for the wedge dam.

Design – Use one log to span the entire stream. Place braces on the lower side at about 45 degrees to the main log (figures 48 to 50). Add a brace or wing log to the upstream side when leakage around the end is likely to occur, or when unstable banks or streambottom create problems. Use wire and fill material as described in the section on wedge dams. The main log should be at least 16 inches in diameter if available. Dig the log 4- to 6-feet or more into each bank and as deeply into the streambed as possible. Cut a spillway into the log to concentrate low flow to the center of the stream.

Placement – Placement is similar to that described for the wedge dam. However, K dams are best suited for streams less than 15 feet wide.

Advantage – Pools tend to be slightly larger and deeper than those created by wedge dams, but the wedge dam is more stable and is easier to maintian. A combination of the two structure types enhances the aesthetics of projects in small streams.

Disadvantage – Installation is more difficult and time consuming than for wedge dams because more extensive excavation is required to seat the main log securely in the bank.

A single, large log must be used to span the stream, increasing the difficulty of hand placement. The probability of washing underneath is greater than for the wedge dam because the main log is usually not seated as deeply into the substrate at the center of the stream.

Cost – One structure per crew day can be installed in streams 10 to 15 feet wide.

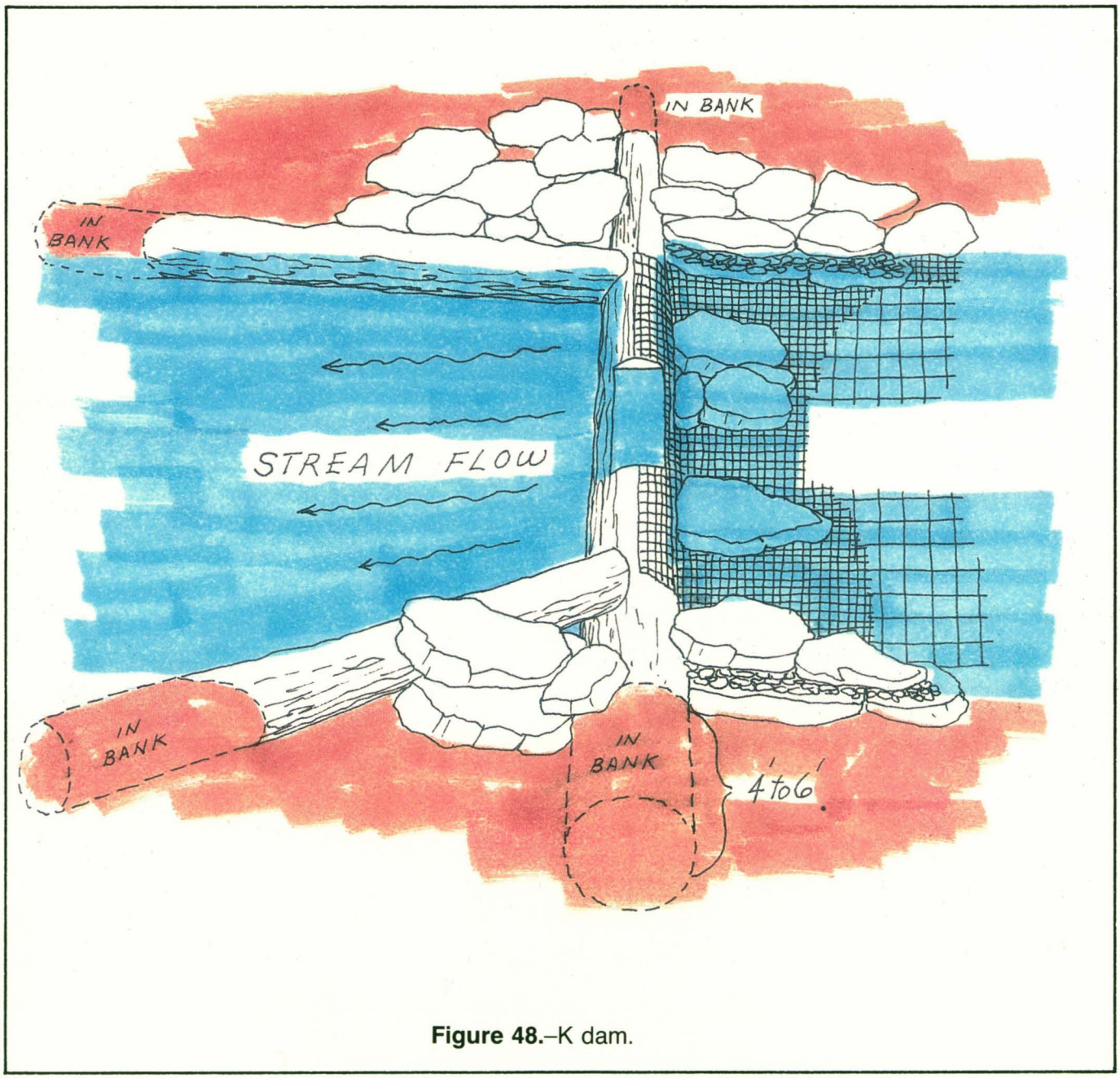


Figure 48.–K dam.

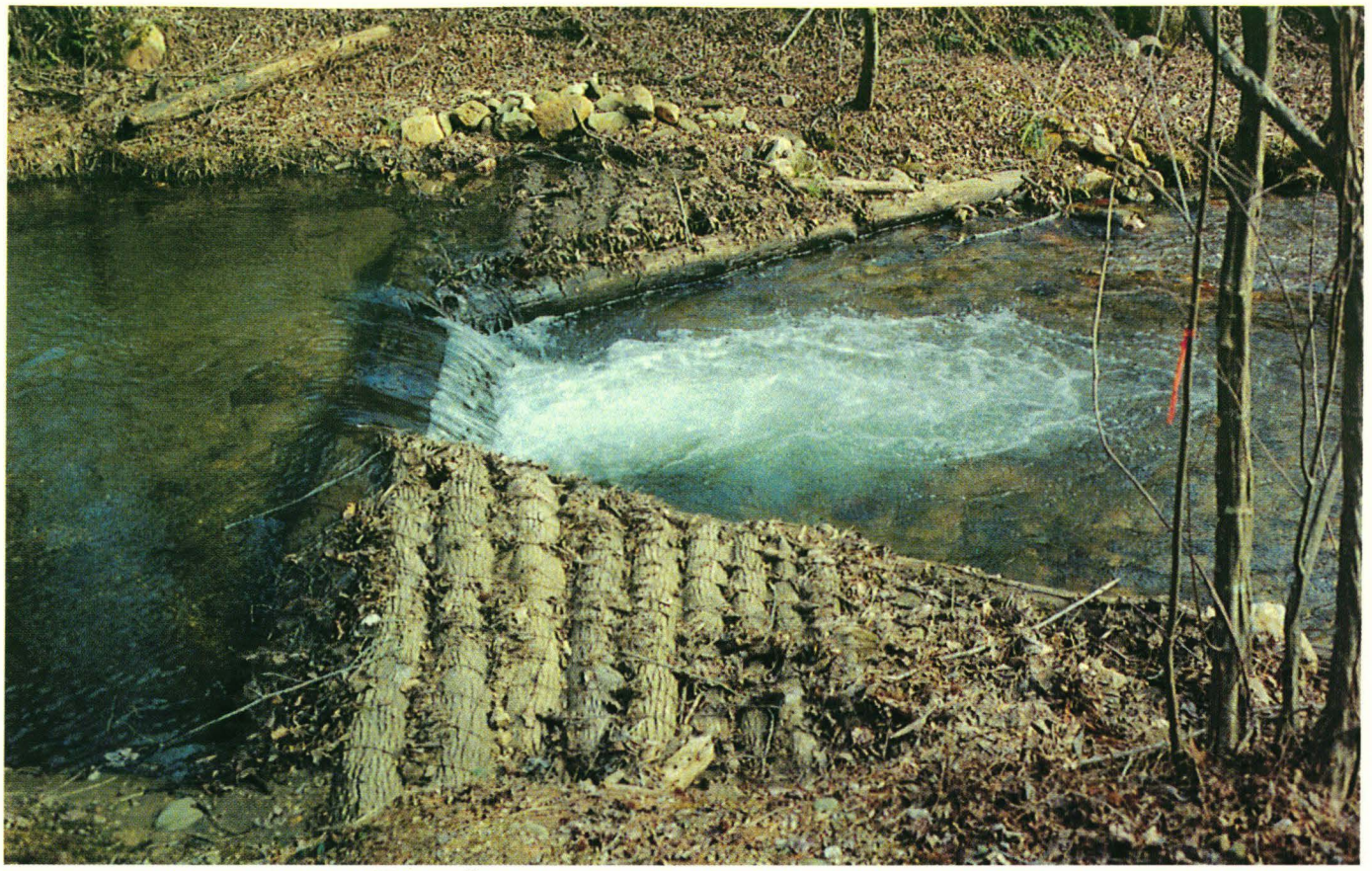
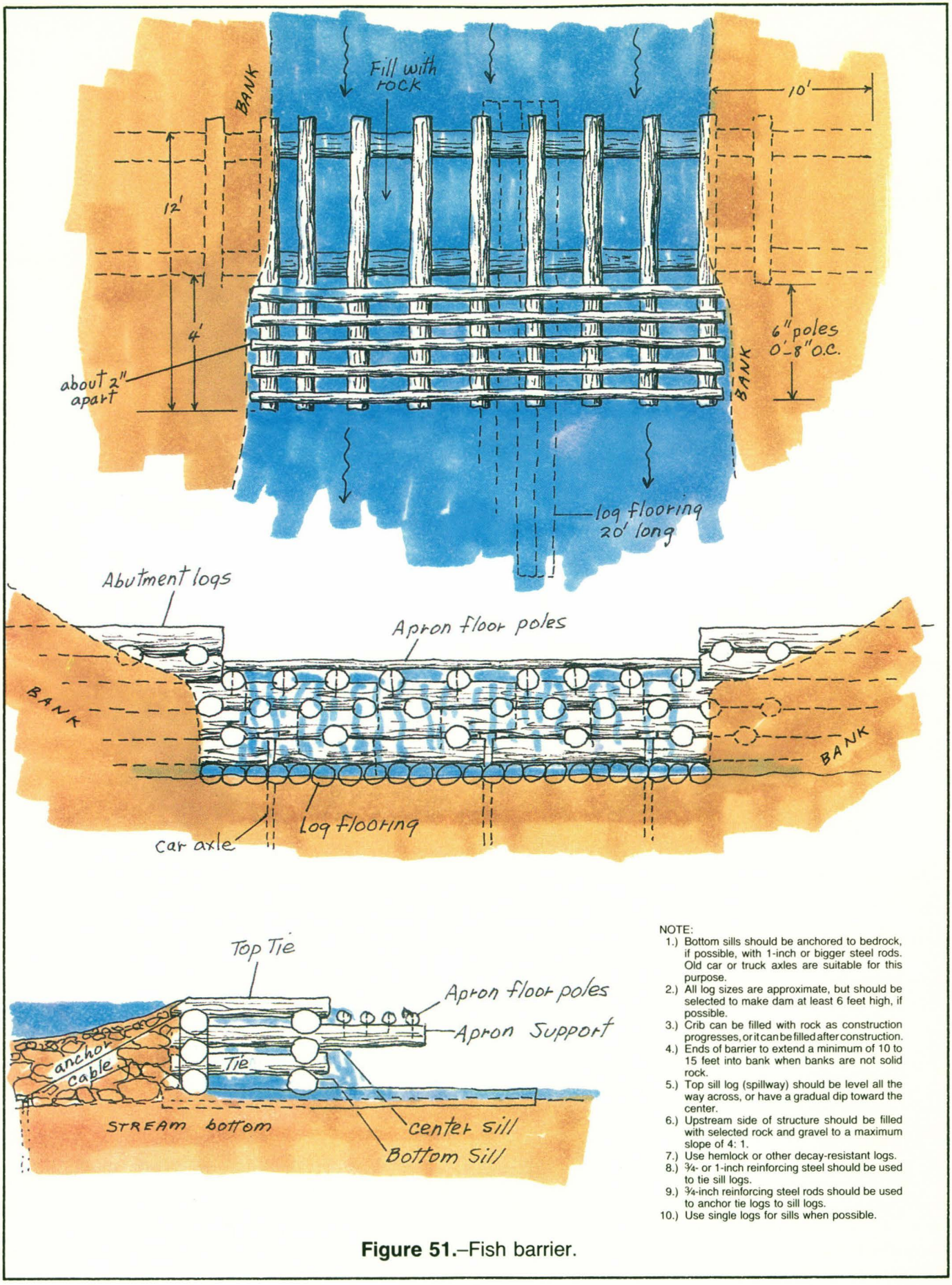


Figure 49.–K dam with log fill in crib.

Figure 50.–K dam.



NOTE:

1.) Bottom sills should be anchored to bedrock, if possible, with 1-inch or bigger steel rods. Old car or truck axles are suitable for this purpose.
2.) All log sizes are approximate, but should be selected to make dam at least 6 feet high, if possible.
3.) Crib can be filled with rock as construction progresses, or it can be filled after construction.
4.) Ends of barrier to extend a minimum of 10 to 15 feet into bank when banks are not solid rock.
5.) Top sill log (spillway) should be level all the way across, or have a gradual dip toward the center.
6.) Upstream side of structure should be filled with selected rock and gravel to a maximum slope of 4: 1.
7.) Use hemlock or other decay-resistant logs.
8.) ¾- or 1-inch reinforcing steel should be used to tie sill logs.
9.) ¾-inch reinforcing steel rods should be used to anchor tie logs to sill logs.
10.) Use single logs for sills when possible.

Figure 51.–Fish barrier.

Fish Barrier

Purpose – Prevents the upstream migration of undesirable species of fish. In some cases, the objective is to exclude warmwater fish from waters managed for trout. In other cases, the objective might be to exclude rainbow and brown trout from brook-trout waters.

Design – The design is basically a log crib filled with rock, incorporating a log apron and log floor to reduce chances of fish jumping the barrier (figures 51 to 57). Overall height of the structure can be 6 feet or less since the log flooring precludes formation of a jump pool. The pool above the structure should be backfilled with coarse rubble and boulders when available.

Placement – In selecting a location, it is essential that streambanks be high enough to handle flood flow without bypassing the structure. Use a cable or attach the structure to bedrock when possible.

Cost – Heavy equipment is essential when building barriers on streams over 20 feet wide. A front-end loader is considerably more cost effective than hand labor when moving large logs and fill material. A crew of eight to ten workers with heavy equipment, logs, gravel, and other materials conveniently available can complete a structure on a 20- to 30-foot wide stream in 3 to 4 days.

Gabions

Where proper size rocks are available, gabions can be used in lieu of logs for structure designs such as deflectors, dams, and bank abutments. The durability of gabions on southern streams has been poor, however, when compared to log structures. Other disadvantages include higher costs and poor aesthetics. In general, when logs are available, use them instead of gabions.

Figure 52.–Bulldozer excavating banks.

Figure 53.–Flooring stream bottom with logs.

Figure 54.–Placing sill logs.

Figure 55.–Filling crib with rock.

Figure 56.–Completed fish barrier.

Figure 57.–Water spilling through apron onto log floor.

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Figure 58.–Driving rebar with Cobra drill.

Figure 59.–Logs are heavy!

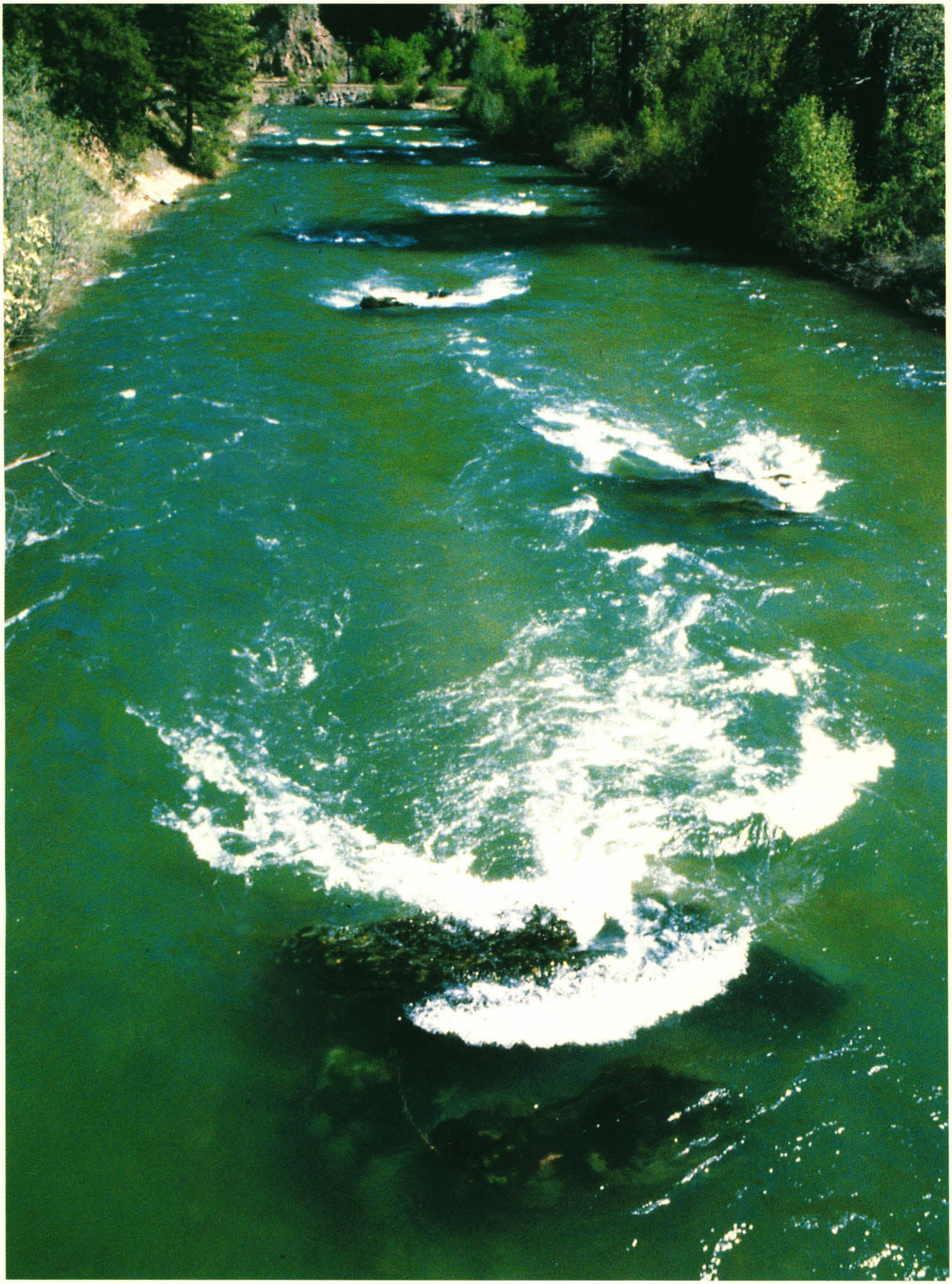

Photo Courtesy of Lola National Forest

Figure 60.–Boulders placed for fish cover.